ECONOMIES OF SCALE IN LOCAL GOVERNMENT: A THEORETICAL FRAMEWORK

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UNITED STATES
DEPARTMENT OF
AGRICULTURE

Working Paper No. 7811

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May 1978

Abstract

A conceptual model is developed for the purpose of providing a framework within which the existence of size economies can be tested. Based on the model the existing size economies literature is shown to be faulty on several counts. First, a simultaneous system of equations is shown to be necessary in order to test for size economies though most previous literature uses a single equation approach. Second, most previous studies have ignored capital costs which results in estimates of short run rather than long run cost curves. Also, the paper notes that care must be taken in application of size economies research to policy questions.

Keywords: Size economies, local government costs, scale economies, consolidation, growth.

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ECONOMIES OF SIZE IN LOCAL GOVERNMENT:
A THEORETICAL FRAMEWORK

by William F. Fox

Introduction

In an effort to improve the efficiency of local governments, economists and political scientists have attempted to apply micro-economic principles to government production of goods and services. The existence of one principle of economic theory, more than any other, has been examined for local governments--that of size economies. Over 120 articles, books, and monographs have been devoted to studying the existence of size economies (Fox, 1978b). The literature also is peppered with expenditure studies (Fredland, 1974) many of which purport to provide evidence on size economies and numerous treatises which apply size economies research when examining local government structures.

Many advances in understanding government behavior can be attributed partially or wholly to the search for size economies. For example, the understanding that per capita expenditures or the size of the population served do not measure the output of a local government service has led to a search for more meaningful measures of local government output. Despite some peripheral benefits from the size economies literature it still remains difficult to have confidence in the empirical results to date. The overriding problem in the literature is the failure of analysts to develop a theoretical framework within which the existence of size economies can be tested. Incomplete theory has led to unreliable or useless tests of size economies and improper application of the results. The remainder of this paper is devoted to development of a

*An earlier draft of this paper was presented at the Midwest Political Science Association Meetings April 21, 1978.

theoretical framework for examining size economies. The size economies literature on education will then be examined to see how closely previous studies fit into this framework.

A Model of Local Government Behavior 1/

Assume that local governments seek to enhance the well-being of all, or some subset, of their citizens. Then local governments may be fruitfully analyzed in terms of their behavior as joint producer-consumers of goods and services. In doing so, distinctions may be made between the roles of producer and consumer. In their role as producers local governments should be concerned with such factors as input costs and the appropriate choice of inputs in producing goods and services. The role as consumer finds these governments concerned with financing and obtaining services with the goal of satisfying desires.

A variation on the traditional supply-demand analysis which is employed by economists permits the two dimensions of local government behavior to be analyzed. The producer role may be viewed as describing the supply side of the market for services and the consumer role represents the demand side of the market.

Size economies refers to the relationship between output and the per unit cost of producing the output. This is an issue concerned with the supply side behavior of local governments. Therefore, care must be taken to isolate the government's role as supplier from its role as demander (consumer), when testing for size economies. However, this may not be achieved independently of the demand for services. Observable output, price relationships represent intersections of supply and demand. Efforts to examine supply alone would yield a relationship between the observed intersections which would most likely bear no relationship to supply and the costs of production.

Consider the demand for local services. First, to be useful, demand must be analyzed in terms of that set of citizens who are responsible for the decision of the service levels to provide. This set of citizens may be members of a political party or a group with homogeneous tastes, or median voters. In general, demand for the decisive group of citizens may be analyzed in terms of its traditional determinants--price of the service, prices of substitutes and complements, income, and tastes.

Several variations on the simple demand model arise, however, because of the unique nature of government services. One variation centers on the price paid by citizens for the service. Price refers to the per unit amount paid by local citizens to finance the service and should be distinguished from the supply side measure of average cost, which is expenditures on the inputs divided by the number of output units produced. Federal and State grants to local governments may be one source of price reduction for the citizens of local governments. Also, nonresidential tax sources--industry, commerce, and tourism--may reduce the tax price paid by local citizens. Therefore, the demand for services will be partially determined by the availability of grants-in-aid and nonresident tax sources.

A second variation in demand analysis involves the distinction between quantity of a service produced and quantity of a service consumed. The distinction arises because producers and consumers view output differently. Producers are likely to see education as teachers and books, while residents envision education as babysitters and improved job prospects. Demand by consumers (the jurisdiction's citizens) must be translated into expenditures for inputs and vice versa. Therefore, to deal with size economies we must state outputs either

in terms of production or consumption. If output is evaluated in terms of production, consumer's demand will depend upon those factors which affect the transformation of a unit of producer's output into a unit of consumer's output. For education, these factors might include preschool training, percentage of handicapped students, and the students' intelligence level. If output is evaluated in terms of the consumer, supply will depend on the same set of factors.

The distinction between producer's and consumer's output also depends on whether the service is a public good. A public good is defined here as a good for which one individual's consumption does not affect the ability of another individual to consume the same unit of the good. Each consumer is presumably interested in their share of the local service rather than the number of units produced. The closer the service is to a public good, the greater the share for each individual. Therefore, the consumer's demand for producer units will depend on how close the service is to being a public good. The preceding discussion permits the demand for any local service to be written as:

(1) $G = G(D, N, P_{G_1} \ldots P_{G_n}, P_{Q1} \ldots P_{Q_m}, I, z, y)$

G = producer's output units of the service
N = population
$P_{G1} \ldots P_{G_n}, P_{Q1} \ldots P_{Q_m}$ = prices of all government and private goods, respectively
I = presence of industrial and commercial tax base
Z = Federal and State grants-in-aid
Y = per family residential income

Supply of services (the producer role of local governments) may be evaluated either in terms of production units or the average cost of providing the service. For size economies it is generally easier to examine the relationship between costs and output so we will concentrate on costs. The supply of local services may be analyzed in terms of the traditional set of variables which influence average costs—the level of input usage, the price of inputs, existing technology,

service conditions, and the level of production. Size economies are then tested through the output-average cost relationship.

One important distinction between the standard supply analysis and local governments' supply may be the decision rule used to select the use of inputs. Cost minimization is usually assumed to determine input usage but factors other than cost may influence government choice of inputs. Desire on the part of bureaucrats to maintain an overly large staff or increase their budget are examples of why input usage may not be at minimum cost. Therefore, additional analysis is necessary in order to incorporate the decision rules for the use of inputs into the examination of size economies. The cost function and input usage equations may be summarized as:

(2) $P_G = P_G(K, L, P_K, P_L, G, S, T)$

(3) $L = L(G, L_{t-1}, E_{t-1}, P_L, P_K, S, T)$

(4) $K = K(G, E_{t-1}, P_K, P_L, S, T)$

K = use of capital to produce the service
L = use of labor to produce the service
P_L, P_K = prices of the inputs
S = service conditions
T = technology
E_{t-1} = last period's expenditures for production of the service

Two approaches are available to test for size economies. One option involves the use of engineering data to simulate local service production because engineering data is purged of interaction effects with demand. This is generallly an infeasible option because the data are expensive. In addition, engineering data assumes cost minimizing use of inputs which, as discussed above, may be an invalid assumption. The second option involves analysis of actual local government behavior. In doing so, we have argued that the estimated model must include equations (1)-(4). Therefore, a simultaneous estimation technique such as two or three stage least squares is required in order to test for size economies.

Previous Research

Size economies research can be classified into basic groups each of which represents a conceptual progression towards a framework much like the one presented above. Each of these groups is discussed below, with examples taken from the literature on the costs of education services. Criticisms are aimed at the group of studies rather than the particular example chosen. Estimation problems are discussed in terms of regression analysis since it is the most common empirical technique used for size economies research.

Empirical research on size economies has obtained widely different conclusions. For example, perusal of nineteen size economies studies for education revealed that eight found size economies, seven found neither economies or diseconomies, one found diseconomies, and three had mixed results. The diverse empirical results fail to provide decisive information about whether size economies exist. This emphasizes the importance of evaluating the literature on the basis of the underlying theoretical structure used in the analysis.

Ad Hoc Expenditure Studies

Generally, the earliest size economy research was composed of ad hoc expenditure studies. These reduce the multiple equation system discussed above into one equation with average cost as the dependent variable and then observe the relationship between average cost and output (generally measured by population served) to test for size economies. Equation (5) is an example from a study by Osborn (1970). This equation includes surrogates for output, quality, input prices, and demand.

(5) Per pupil expenditures = f_1(ADA, ADA^2, curriculum, test scores, high school ADA/total ADA, teacher salaries, median education of adults, tax levy, assessed valuation per pupil).

Research of this type provides little information on the cost of providing services or on the relationship between costs and scale of service provision. From a theoretical perspective, solving the demand (1) and average cost (2) equations into one equation would eliminate either output or average cost. Conceptually, therefore, both output and average cost should not appear in equation (5). Furthermore, as discussed above size economies refers to the relationship between average costs and level of services provided--it is a supply side phenomenon. The expenditure equation approach, however, does not isolate supply and demand effects. Instead it can be shown that the regression coefficients of the expenditure equation are a function of the structural coefficients from both the demand and supply equation.

An additional problem is that per capita (or per pupil) expenditures are frequently inappropriate as a measure of average cost. Population or school size served are not accurate measures of output because they do not reflect differences in the quality of services provided. In regression analysis this problem can be at least partially accounted for by including quality surrogates as explanatory variables in the regression equation. If the service is price elastic a more serious problem develops. Suppose a price elastic service is characterized by size economies and population is not a good output proxy. If population increases, crowding will probably stimulate increased production of output leading to decreased unit production costs. But as costs fall for a price elastic service, quantity demanded responds so quickly that expenditures rise. Therefore, per capita expenditures may rise and lead to incorrect inferences regarding size economies.

Cost Functions

Another group of studies concentrate on estimating average cost

functions much like equation (2). Equation (6) is an example of a cost function developed by Riew (1966). Included are surrogates for output, output quality, input quality, input prices, service conditions, and time adjustments.

(6) Per pupil expenditures = f_2(ADA, ADA^2, teacher salary, number of credit units offered, average courses taught per teacher, number of classrooms built since 1950, percentage change in enrollment 1957-1960).

Use of per pupil expenditures to measure costs suffers from the problems discussed above for the ad hoc expenditure studies. Therefore, Hirsch (1977) chooses to separate this class of research into two groups: cost studies where output is not measured by population and quasi-cost studies which use population as a proxy for output. Output indexes for the cost studies are theoretically more appropriate but empirically are very difficult to quantify. Cost studies, as distinct from quasi-cost research, still do not overcome the basic simultaneity problem since they use single equation analysis to estimate a simultaneous system.

Another set of problems revolves around the appropriate concept of cost. An example of the problems is illustrated by police protection where costs have been variously measured by social costs (Morris, 1973) total expenditures plus total unrecovered losses (Popp and Sebold, 1972), operating costs, and others. While most studies of size economies have focused on agency costs, the appropriate concept of cost depends on the purpose for the research. Social costs, which include a measure of benefits or demand, are useful for measuring the impact of services on people. For analysis of budgets and optimal size of the production unit, however, agency costs are more appropriate.

If the decision is made to use agency costs, a new difficulty

arises--what set of agency costs should be included. Among the options for education are operating costs less transportation, operating costs, yearly expenditures, and operating costs plus depreciation. Riew used operating costs less transportation, the most commonly adopted measure of costs, and noted that they represent 63 percent of total education expenditures. Capital usage is omitted from the common measure of costs because capital purchases occur infrequently and depreciation cannot be measured without information on the value of the capital stock.

A short run average cost curve can be estimated if capital is used as an explanatory variable to hold constant variations in the fixed plant across communities. A serious error occurs in specifying the form of the average cost function if the effect of capital is not held constant. This would cause the regression coefficients to be biased. Furthermore, the error variance would be biased upward causing the test for significant size economies to be too strict (Johnston 1972, p. 169).

If the average cost curve is estimated using capital as a predetermined variable, but with capital costs excluded from total costs, we gain information about the unit cost of providing various levels of education given existing plant capacities. Yet the regression equation fails to examine the potentially more important economies associated with larger plant capacity and better long run use of capital.

Production Functions

As noted above, supply may be analyzed either in terms of an average cost function or a production function. A production function is similar to an average cost function (equation 2) except input prices do not enter the equation. One example of the production function approach is shown in equation (7) (Kiesling, 1967).

(7) Average Achievement Test Score = f_3(ADA, expenditures per pupil, intelligence score)

Production functions can be a useful approach for avoiding difficulties associated with the measurement of costs. Production functions have been analyzed less frequently than cost equations, however, because a single index of output is difficult to define. Without an appropriate output measure the production function approach is inoperable.

Consider the production function above. Average achievement test score, a quality measure representing output, and average daily attendance (ADA) are used to examine the relationship between size and output. Expenditures per pupil measure school inputs and intelligence score is a surrogate for pupil input. The regression coefficient for ADA relates quality to quantity with inputs held constant. This coefficient tells how many quality units must be sacrificed for each additional unit of quantity produced. Expenditures, clearly a poor surrogate for inputs, is used to examine size economies.

Previous studies employing production functions have generally ignored the simultaneous decisions regarding the choice of output and the inputs in the production process. It can be shown that this leads the hiring of inputs to be functionally related to the error term in estimating the production function. Therefore, an assumption of least squares regression analysis is violated (Hoch, 1958) if additional equations are not developed to determine the use of capital and labor.2/

Theoretically Derived Expenditure Functions

An example of a theoretically derived expenditure function by Borcherding and Deacon (1972) is shown in equation (8).

(8) Per pupil expenditures = f_4(wage rate, population, income, degree of urganization)

This category is useful because it represents a conceptual step forward. In theoretical terms both the supply and demand for local services are examined in this approach. In order to overcome the problem of output measurements, however, these studies obtain a reduced form expenditure equation by multiplying demand times supply. Then the common assumption is that services are produced at constant average cost, so the regression equation represents only demand side analysis. From an empirical perspective this research obviously provides no information on size economies because the presence of a size-average cost relationship is assumed away.

Identified Model

Identified models of local service output represent the most advanced class of size economies research. Studies falling into this group have explicitly sought to take into account a model much like the one proposed above. This approach involves examining the demand and supply of local services and the decision rules for the use of inputs. Equations (9a) and (9b) come from such a model developed by Harbor, Phillips, and Votey (1973).

(9a) Educational attainment = f_5 (students per capita, teacher input, pupil input, nature of the community)

(9b) Teacher input = f_6 (educational attainment, income per capita, students per capita)

Equation (9a) is the educational production function (corresponding to equation 2) and equation (9b) is a combination of the demand for education equation (1) and the use of labor equation (3) made possible by several simplifying assumptions. The advantage of a model like this is that it permits isolation of the demand and supply factors involved in local government behavior.

Research of this type represents a significant step towards a conceptually sound analysis of size economies. Yet, there remain some problems associated with this model. First, as noted above for the production function approach, failure to hold capital constant in the production equation makes it difficult to interpret the results unless capital can be deemed an unimportant input. King and Wall (1977) used engineering data to demonstrate that gymnasiums are important elements in size economies for education and they argued that other capital facilities may also be important. Therefore, omission of capital from equation (9a) makes meaningful interpretation of the regression results difficult. An additional problem with this study is its measurement of teacher input by per pupil teacher expenditures.

Implications

Tests of size economies have been applied by numerous researchers to many different local services. Little value can be derived from continuing to test for size economies using traditional data sets and elementary models. Research is needed, not to replicate old analyses, but to deal with some conceptual and empirical issues surrounding application of a model such as the one suggested above. Two conceptual issues are further identification of the inputs in the production process for local services and better understanding of the relationship between inputs and outputs.

Several major empirical problems also remain. Precise tests of size economies still await development of quantifiable measures of local government services.3/ Second, data on the size and value of capital stocks must be gathered and included in size economies research. Analysis of short run average cost curves or the relationship between labor and output is generally not sufficient to answer questions

related to size economies and more research in this vein appears unprofitable except for a few services in which capital costs are clearly unimportant.

Application of Size Economies Results

Four questions might be asked regarding local government costs and output of services: (1) should local governments be consolidated, (2) what happens to costs of services as population grows, (3) what is the optimum city size, and (4) what happens to costs if services are increased for the existing population? Only the fourth question can be answered solely with size economies research. Each of the other issues involve complicating issues which size economies research per se does not fully address.

Whether to consolidate local governments involves determining costs of local services for various city sizes. However, costs associated with the increased area served must also be considered. Depending on the service analyzed, area costs would include such factors as transportation for larger school districts and the costs of laying water and sewer lines. Even ignoring the area costs, it can be shown that the requirement of size economies for consolidation to be cost saving is too strenuous a test (Fox, 1978a).

Size economies research provides information on how costs will adjust as populations grow or decline, yet the size economies data is insufficient to predict changing budgetary conditions facing a local government. Increased population density will increase the demand for many services--police and fire protection, for example. Furthermore, the population characteristics of new residents may alter the demand for services.

Finally, size economies for local services are insignificant in

the decision of optimal city sizes. Pollution costs and congestion and private agglomeration benefits far outweigh the importance of local services in optimal city size.

Therefore, not only must care be taken in attaching importance to the size economies findings of existing literature, but care must also be taken when using the presence or absence of size economies to justify some policy action. All relevant considerations must be brought into the analysis of policy decisions and size economies are generally only one part.

Footnotes

1/ Appendix A contains a more precise, theoretical discussion of the model.

2/ An assumption of ordinary least squares is not violated if it can be assumed that local governments seek to maximize anticipated rather than current output (Hoch, 1962).

3/ A discussion of problems associated with measurement of education output and some possible solutions are contained in Levin (1974).

Appendix A

This appendix develops in more precise terms a model of local government behavior. This model establishes a system within which the cost-output relationship can be evaluated. An optimization model is adopted because it represents an approach in which services are efficiently provided. This seems desirable since issues of production and size economies are studies of efficiency. Also, and perhaps more important, an optimization model yields specific testable hypotheses.

Demand

The first step in developing a system which models local government behavior must be consideration of the demand for government services. Demand, in an optimization model, is evaluated by accepting a specific utility function and then maximizing it subject to whatever constraints the government faces. But whose utility is being maximized and what is the form of the function?

The economics literature appears to be dominated by variations on two explanations of how individual preferences for services are translated into actual production. One is the median voter approach, which sees demand for services being conveyed by a decisive subset of local citizens. Continuous interactions between the citizens lead to decisions on the optimal level of output. This approach is appropriate for situations when local governments can be assumed to operate in a Tiebout world--one in which people vote with their feet.

The dominant party model is the other approach. Within this approach to utility translation, a single group wins control of decision making for a specified time period and sets service and expenditure levels according to its utility function. The dominant party must, of course, keep an eye on the next election. The median

voter model is accepted for this paper because it seems more appropriate for small and medium size cities, where the Tiebout world can be most closely approximated. It should also be noted that most studies of size economies have centered on small to moderate size cities.

Assume, as shown in equation (1), a utility function dependent upon the level of government services consumed by the median voter (G_i^*) and the amount of private goods (Q_j) available to the median or representative voter. The level of government services consumed by the median voter must be distinguished from physical production of services, G (equation 2). This distinction is important because producers are likely to see education in terms of teachers and books, while residents envision education as babysitters and improved job prospects. D_i is a vector of service characteristics which converts production units to consumption units (King, 1977). Population (N) is included in defining G * in order to account for the degree to which local services are pure "Samuelsonian" public goods. If $\alpha = 0$ the local service is purely public, but if $\alpha > 0$ some crowding out occurs in the consumption of the local services.

(1) $U = U(G_i^*, Q_j)$

(2) $G_i^* = \frac{G_i^*}{D_i} \cdot N^{-\alpha}$ for all i

Optimal provision of G * is determined by maximizing equation one subject to the budget constraint presented in equation three. The budget constraint shows that total spending for public services ($\sum_i P_{Gi}G_i$) plus total spending for private goods ($\sum_j P_{Qj}Q_j$) minus business property taxes paid at a uniform rate t on industrial and commercial property (I) minus intergovernmental transfers (z) must equal residential income (y) where P stands for the prices of the goods. The income constraint adopted assumes only exogenous intergovernmental transfers are made and

that the responsiveness of industry to tax rate changes can be ignored.

$$(3) \sum_i P_{G_i} G_i + \sum_j P_{Q_j} Q_j - tI - z - y = 0$$

The first order conditions, derived by differentiating equation one subject to the budget constraint with respect to the choice variables G and Q, can be solved for all i demand equations for the local service outputs1/ and all j demand equations for private goods. Demand equations for the local services are shown to be a function of the vector of service conditions, population, prices of all goods, amount of nonresidential property, intergovernmental grants, and income.2/

$$(4)\ G_i = G_i(D_i, N, P_{G_1} \ldots P_{G_n}, P_{Q1} \ldots P_{Q_m}, I, z, y) \qquad \text{for all } i$$

Supply

A production function relates inputs to outputs and a cost function shows the cost of providing various levels of output. Applications of duality theory to production and costs have shown that under certain regularity conditions a particular production function implies a given cost function and vice versa. Therefore, the supply aspects of our system can be modeled either in terms of production or cost functions. A cost function will be modeled here since most size economies studies have adopted this approach.

The production function (equation 5) relates the various inputs to production of outputs. For simplicity assume that production is a function of capital (K_i), labor (L_i), service conditions (S_i), and technology (T_i). The local government should attempt to minimize the cost of producing each level of output so the average cost curve (equation 7) can be derived by minimizing the production function subject to the cost constraints (equation 6).

$$(5)\ G_i = f_i(K_i, L_i, S_i, T_i) \qquad \text{for all } i$$

$$(6)\ P_{G_i} G_i = P_{L_i} L_i + P_{K_{it}} K_{it} \qquad \text{for all } i$$

(7) $P_{G_i} = P_{G_i}(K_i, L_i, P_{K_i}, P_{L_i}, G_i, S, T)$ for all i

Developing the demand and average cost relationships is not sufficient, however, to provide a completely identified system. The individuals making production decisions are also determining the appropriate use of capital and labor. An additional equation is necessary for each input in order to account for the decision rule involved in selecting the appropriate use of inputs.

The decision rule for use of inputs will probably relate the desired level of inputs to the level of output to be produced and the price of inputs. There may, however, be certain bureaucratic constraints which prevent governments from choosing inputs so that they operate at minimum costs. Two hypotheses about how bureaucracy affects the production process are (1) bureaucrats seek to maximize the agency budget rather than minimize costs and (2) bureaucrats seek to operate with an above-minimum-cost staff (Orzechowski 1977). The first hypothesis can be at least partially taken into account by constraining this year's budget to at minimum equal last year's budget. Inefficient use of staff can be considered in a similar manner by making last year's staff a minimum for this year. Equations (8) and (9) show the bureaucratic constraints and equations (10) and (11) represent the purchase of inputs.

(8) $P_{G_{it}} G_{it} \geq P_{G_{it-1}} G_{it-1}$ for all i

(9) $L_{it} \geq L_{it-1}$ for all i

(10) $L_{it} = L_{it}(G_{it}, L_{it-1}, P_{G_{it-1}} G_{it-1}, P_{L_{it}}, P_{K_{it}}, S, T)$ for all i

(11) $K_{it} = K_{it}(G_{it}, P_{G_{it-1}} G_{it-1}, P_{K_{it}}, P_{L_{it}}, S, T)$ for all i

Equations (4), (7), (10), and (11) provide a system of four equations with four unknowns: G_{it}, $P_{G_{it}}$, K_{it}, and L_{it}. Interactions between the variables require that the system be estimated using a simultaneous equations estimation technique such as two or three stage

least squares. Solution of this system of equations should provide unbiased and consistent estimators of the regression coefficients. Then the output coefficient in equation (7) can be examined to determine the existence of size economies.

Footnotes to Appendix A

1/ G and G* are definitionally related by equation (2) so demand could be stated in terms of either. Legitimate arguments can be made for evaluating demand in terms of either measure of output. However, since size economies is a study of efficiency in production, we have chosen to measure demand in terms of producer's output.

2/ If this study were focusing on demand for local government services, and in particular, the price elasticity of demand, the tax share should be included as the price. For supply side analysis of size economies, however, average cost is a more useful measure of cost. Of course when average cost measures price, the demand equation must hold constant nonresident revenue sources.

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